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A bronze medal struck in memory of the late Frederick Thiersch, presented by the Royal Bavarian Academy, was received and exhibited.

Professor H. J. Clark made a detailed communication upon the group of Medusæ of which Lucinaria is the type, — a group which he finds now to consist of two families and seven if not eight genera, the characters and structure of which were illustrated.

Dr. Dexter made a communication upon Revolving Storms, in particular upon one of June last, which he had observed and investigated.

Mr. Safford remarked upon certain forms of personal equations.

Professor B. Peirce commented upon certain remarks upon the American Lunar Tables contained in a recent volume of the Transactions of the Royal Astronomical Society.

### Five hundred and seventeenth meeting.

January 28, 1863. — STATUTE MEETING.

THE PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges of the Academy.

An artist's proof of Mr. Marshall's engraving of Stuart's portrait of Washington, presented by the engraver, was exhibited, and ordered to be appropriately framed.

On motion of Mr. Folsom, the thanks of the Academy were voted to Mr. Wm. E. Marshall for this valuable donation.

Capt. Henry L. Abbot, U. S. Topographical Engineers, was elected a Fellow, in Class I., Section 4.

Wm. W. Story, Esq., was elected a Fellow in Class III., Section 4.

General A. A. Humphreys, U. S. A., was elected an Associate Fellow, in Class I., Section 4.

Christopher Hansteen, of Christiania, Norway, was elected a Foreign Honorary Member, to fill the vacancy left in Class I., Section 3, by the death of Biot.

Leopold von Ranke, of Berlin, was elected a Foreign Honorary Member in place of the late Sir Francis Palgrave, of Class III., Section 3.

Mr. Alvan Clark read a paper entitled "The Sun a small Star."

Professor B. Peirce made a communication on the vibration of solids floating in water, in reference to the displacement and stability of vessels in a heavy sea.

The following paper was presented

## *On the Aluminates of Baryta*, by W. P. DEXTER.

M. H. Sainte-Claire Deville has described, in the *Comptes Rendus* for February, 1862, a "very curious compound," an aluminate of baryta, soluble in about ten parts of water, and which can be made to crystallize out of alcohol. The composition assigned to the crystals is one atom of alumina, one of baryta, and four of water. The analysis, however, leaves it uncertain whether they contain four or three atoms of water.

The existence of a compound of alumina and baryta has been long known to chemists. The solubility of alumina in solution of baryta is mentioned by Berzelius,* who states that alumina acts as an acid in relation to the alkalies, the alkaline earths, and some of the stronger metallic bases. And Vauquelin† speaks of two compounds, the one soluble, containing more baryta, the other insoluble, and containing excess of alumina.

According to Unverdorben,‡ a neutral aluminate can be obtained by dissolving alumina in caustic potash, evaporating to dryness, and taking up the excess of potash with alcohol. Its solution gave, with chloride of barium, a gelatinous precipitate, containing equal equivalents of alumina and baryta, and the aluminates of other bases could be precipitated in the same way. The solution of alumina in excess of potash gave, with the chlorides of barium and calcium, precipitates resembling the former, but containing two equivalents of baryta to one of alumina; they were dialuminates.

The analyses of these compounds given by Unverdorben agree so precisely with the equivalent numbers at that time in use, that I cannot but think, considering the difficulty of obtaining in a pure state precipitates of a gelatinous consistency and decomposable by the carbonic acid of the air, that he has given the calculated numbers, and not the results of his analyses.

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* Traité de Chimie, Tom. II. p. 155 (Paris, 1846).

† L. Gmelin, Bd. II. s. 296.

‡ Pogg. Ann., Bd. VII.

This subject was studied by me several years ago; the results of that investigation I have now the honor of laying before the Academy.

On repeating Unverdorben's experiment, I found that neutral aluminate of potash gives, as he states, a precipitate with chloride of barium; much alumina, however, remained in solution, and on attempting to wash the aluminate of baryta, the greater part of it dissolved and passed through the filter.

When freshly precipitated alumina is dissolved in hot concentrated solution of baryta, a compound of these bodies separates in minute crystals, which attach themselves to the sides of the vessel. If the solution is dilute, it must be concentrated; the crystals then form suddenly during the evaporation, and adhere so strongly to the glass that it is difficult to remove them by mechanical means. They are transparent, colorless, are hard and heavy, and, while covered by the liquid, have an almost adamantine lustre. They are decomposed by the carbonic acid of the air, and by water, which separates from them alumina. For these reasons, and from their adhesion to the glass, it is somewhat difficult to collect them for analysis.

1.0605 gr. of these crystals gave 0.972 sulphate of baryta and 0.2197 alumina; whence we have for their composition,

| | Found. | Equivalents. | Calculated. | |
|---|---|---|---|---|
| | | | 6 H O. | 5 H O. |
| $BaO$ | 60.18 | 1.96 | 59.25 | 61.39 |
| $Al_2O_3$ | 20.62 | 1.00 | 19.86 | 20.58 |
| $HO$ | 19.20 | 5.32 | 20.89 | 18.03 |
| | 100 | | 100 | 100 |

It is doubtful whether the salt contains 6 or 5 atoms of water; perhaps the more probable formula is

$$2\,BaO,\ Al_2O_3,\ 6\,HO.$$

In a preparation in which the baryta had been boiled with a considerable excess of alumina, the liquid separated from the crystals was evaporated *in vacuo* over sulphuric acid to dryness. There remained an amorphous, friable, white mass, containing, exclusive of water,

| | |
|---|---|
| $BaO$ | 69.46 |
| $Al_2O_3$ | 30.54 |

These numbers are not in atomic proportion; and the mass was a mixture of aluminate and dialuminate.

In a similar liquid, but of another preparation, alcohol produced an amorphous precipitate of nearly the same composition.

The analysis gave

| | |
|---|---|
| $BaO$ | 65.70 |
| $Al_2O_3$ | 34.30 |
| | 100 |

being intermediate between the neutral aluminate, which requires 59.86, and the dialuminate, in which is 75 per cent of baryta.

It is easy to obtain, by a different process, a solution containing alumina and baryta in nearly the proportion of equal atoms, but many attempts which I made to separate the salt proved unsuccessful; only once was I able to get a body having this composition, and on repeating that process it gave me a different result.

A mixture of carbonate of baryta and chloride of sodium fuses at a very moderate temperature and without decomposition. If alumina be added to the melted mass, or to the mixture before ignition, a brisk disengagement of carbonic acid ensues. Water dissolves from the mass, beside the chloride of sodium, a considerable quantity of neutral aluminate of baryta, or more probably, as will presently appear, a double salt of aluminate of baryta and chloride of sodium. The solution is unaffected by caustic alkalies; acids and chloride of ammonium precipitate the alumina, the latter with disengagement of ammonia. Equal equivalents of alumina and carbonate having been thus fused, and the mass digested with water, the solution gave on analysis,

| | |
|---|---|
| $BaO$ | 63.51 |
| $Al_2O_3$ | 36.49 |
| | 100 |

or from five to six per cent more baryta than is required by the composition of the neutral aluminate.

Thinking that the excess of baryta would be precipitated by carbonic acid before the baryta contained in the neutral aluminate was acted upon, a similar solution was exposed, with frequent agitation, to the air, or a stream of carbonic acid was led through it until with the carbonate of baryta a sensible quantity of alumina was precipitated. The liquid then contained

| | |
|---|---|
| $BaO$ | 62 |
| $Al_2O_3$ | 38 |
| | 100 |

being nearly $3\frac{1}{2}$ per cent of baryta in excess.

With the same view, to another solution a very dilute hydrochloric acid of known strength was added until a precipitate of alumina became visible. But the quantity of acid which could be so added corresponded to only the half of one per cent of baryta; deducting this amount, the liquid contained

| | |
|---|---|
| $BaO$ | 61.44 |
| $Al_2O_3$ | 38.56 |
| | 100 |

A solution giving the same reactions may be obtained by fusing carbonate of baryta and alumina with other chlorides, or with salts of a similar chemical nature. By employing a salt easily soluble in alcohol, I hoped to be able to separate the aluminate. To this end 5 parts of carbonate of baryta and 2 of alumina were fused with 10 parts of bromide of sodium, the mass dissolved in water, and evaporated in a water-bath under a pressure less than that of the atmosphere, and finally *in vacuo* over sulphuric acid. The residue was digested with alcohol, brought upon a filter and washed with alcohol till the washings contained only a trace of bromine. The mass was then only partially soluble in water, the solution gave the reactions of aluminate of baryta, but contained a great deal of bromine. In fact, under these circumstances a double salt of aluminate and bromide is formed which is insoluble in alcohol. If the simple aluminate be really soluble in alcohol, as would be inferred from the statement of M. Deville, it is not easy to understand how its combination with bromide of sodium should be nearly insoluble in that liquid.

Finally, carbonate of baryta was fused with fluor-spar and alumina. The fusion is easily effected, the fluor-spar is apparently not decomposed, and the aluminate is formed as in the former cases. The fused mass was very finely pulverized and digested with water, which could here dissolve nothing but the aluminate. The solution contained

| | |
|---|---|
| $BaO$ | 70.5 |
| $Al_2O_3$ | 29.5 |
| | 100 |

which is not very far from the composition of the dialuminate already described.

Another solution made in the same way was evaporated until the salt began to separate, and then precipitated with twice its volume of alcohol and the precipitate washed with alcohol: it was found to be composed of

| | |
|---|---|
| $BaO$ | 62.84 |
| $Al_2O_3$ | 37.16 |
| | 100 |

When this precipitate was treated with water, it dissolved only partially, leaving a considerable residue of alumina. This seems to show that the neutral aluminate is not soluble without decomposition in water, and to explain why in its solutions the baryta was invariably found in excess.

Beside the reactions which have been already mentioned as characterizing the aluminates, the solution of the precipitate by alcohol (which was found to contain 64 per cent of baryta and 36 of alumina) gave with nitrate of silver a voluminous, flocculent, chocolate-colored precipitate, subsiding quickly in the liquid, and soluble in ammonia with very little residue. The ammoniacal solution acidified with nitric acid, and then saturated with ammonia, let fall a large quantity of alumina.

With acetate of copper it gave a precipitate of a delicate blue color, in other respects resembling alumina: it was completely soluble in ammonia, and from the ammoniacal solution the alumina was precipitated by chloride of ammonium.

A concentrated solution of chloride of calcium produced at once a white flocculent precipitate, very easily and completely soluble in dilute nitric acid: in a dilute solution of the same salt no precipitate was formed.

The analysis was in every case effected by first separating the baryta as sulphate, then neutralizing with ammonia and completing the precipitation of the alumina with sulphide of ammonium. The alumina was removed with a spatula from the filter after being incompletely washed, redissolved in hydrochloric acid, the filter washed with this acid and the alumina again precipitated and collected upon the same filter.

While endeavoring to obtain the neutral aluminate of baryta, I observed two double salts of the aluminate with chloride of barium, and others doubtless may be formed in the same way. When chloride of aluminium, which for this purpose is most easily formed by precipitating sulphate of alumina with chloride of barium, is added to a hot solution of baryta, chloride of barium is of course formed, and the separated alumina redissolves in the excess of baryta. By further addition of the chloride a permanent precipitate appears, which consists of alumina combined with a small quantity of baryta. The filtered liquid deposits on evaporation crystals, *apparently* rhombic tables and prisms, which are not so hard and do not attach themselves so firmly to the glass as the crystals of the dialuminate. They contain chlorine, and are soluble in hot water, giving a slightly turbid solution: cold water dissolves them less easily, but does not extract the chlorine, which is found in the washings until they are completely dissolved. In *concentrated* solution of baryta they were only partially soluble; what remained, after being dried by pressure in paper, was free from chlorine and composed of

| | |
|---|---|
| $Ba\,O$ | 62.11 |
| $Al_2\,O_3$ | 37.89 |
| | 100 |

being very nearly the composition of the aluminate previously obtained, and probably as a double salt, by fusing alumina and carbonate of baryta with chloride of sodium, — a neutral aluminate of baryta with slight excess of base. In the moist state it was little soluble in very concentrated solution of baryta, but dissolved at once on dilution with water.

On repeating the experiment I failed to obtain this body; owing perhaps to insufficient concentration of the baryta, the crystals dissolved in it without residue.

The crystals of the double salt, dried between folds of paper, lost *in vacuo* over sulphuric acid 0.23 per cent, evidently adhering moisture. 0.7137 gr. then gave 0.6078 $Ag\,Cl$, 0.6692 $Ba\,O, S\,O_3$, and 0.0692 $Al_2\,O_3$; from which their composition appears to have been

| | | Equivalents. |
|---|---|---|
| $Ba\,Cl$ | 61.76 | 3.00 |
| $Ba\,O$ | 16.15 | 1.07 |
| $Al_2\,O_3$ | 9.69 | 0.95 |
| $H\,O$ | (12.40) | 6.97 |
| | 100 | |

and is represented by the formula

$$3\,Ba\,Cl,\ Ba\,O\,Al_2\,O_3,\ 7\,H\,O.$$

The aluminate contained in the double salt consisted of

| | |
|---|---|
| $Ba\,O$ | 62.50 |
| $Al_2\,O_3$ | 37.50 |
| | 100 |

The aluminate thus appears to have had in combination with chloride of barium almost exactly the same composition, the same excess of base, which was found in it when uncombined, by the former analyses.

The liquid which had been decanted from the crystals just described, let fall, after standing well covered for some hours, a snow-white crystalline powder in considerable quantity. This powder, which seemed to be free from crystals of hydrate of baryta, when compressed between paper became of a plastic or cheesy consistency. It was not washed. The analysis gave the following results: 0.566 gr. weighed, after remaining *in vacuo* over sulphuric acid till the weight became constant, 0.4232; of this, 0.423 gave 0.2076 $Ag\,Cl$, 0.3476 $Ba\,O\,S\,O_3$, and 0.073 $Al_2\,O_3$, whence we have the composition,

| | | Equivalents. |
|---|---|---|
| $Ba\,Cl$ | 26.58 | 1.00 |
| $Ba\,O$ | 20.79 | 1.06 |
| $Al_2\,O_3$ | 12.90 | 0.98 |
| $H\,O$ | (14.51) | 6.31 |
| Aq | 25.22 | 10.98 |
| | 100 | |

Aq designating the water lost *in vacuo*. The formula of the salt is then

$$Ba\,Cl,\ Ba\,O\ Al_2\,O_3,\ 6\,H\,O + 11\,Aq.$$

From the difficulty of freeing a body of such consistency from all adhering liquid, and its tendency to absorb carbonic acid during the requisite manipulations, it is very probable that the water may not be correctly given by the above figures.

The aluminate of baryta in the double salt has the composition

| | |
|---|---|
| $Ba\,O$ | 61.71 |
| $Al\,O_3$ | 38.29 |
| | 100 |

which differs little from that previously found for the neutral aluminate.

We know then, in the crystalline state, the following compounds of alumina and baryta: —

A neutral aluminate described by M. Deville,

$$Ba\,O,\ Al_2\,O_3,\ 4\,H\,O;$$

a dialuminate of the formula

$$2\,Ba\,O,\ Al_2\,O_3,\ 6\,H\,O;$$

a double salt of aluminate of baryta and chloride of barium,

$$3\,Ba\,Cl,\ Ba\,O\ Al_2\,O_3,\ 7\,H\,O;$$

and a second double salt, containing the same simple salts, and composed of

$$Ba\,Cl,\ Ba\,O\ Al_2\,O_3,\ 6\,H\,O + 11\,Aq.$$